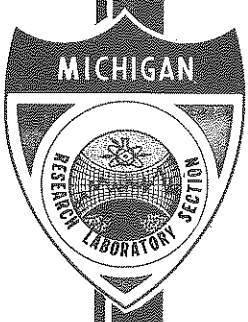
CONSTRUCTION OF A COLD-MIX EMULSION BLACK BASE



MICHIGAN DEPARTMENT OF
STATE HIGHWAYS AND TRANSPORTATION

CONSTRUCTION OF A COLD-MIX EMULSION BLACK BASE

G. F. Sweeney

A Category 2 project conducted in cooperation
with the U. S. Department of Transportation,
Federal Highway Administration

Research Laboratory Section
Testing and Research Division
Research Project 75 E-55
Research Report No. R-1044
Work Plan No. 44

Michigan State Highway Commission
Peter B. Fletcher, Chairman; Carl V. Pellonpaa,
Vice-Chairman, Hannes Meyers, Jr., Weston E. Vivian
John P. Woodford, Director
Lansing, February 1977

INTRODUCTION

This report describes the construction of a roadway using an aggregate, cold-mix emulsion as the base course. The test section was constructed in cooperation with the Federal Highway Administration as a Category 2 project in accordance with Experimental Work Plan No. 44, Research Project 75 E-55.

The project selected for this evaluation was the relocation of a portion of Canal Rd and Billwood Hwy in Eaton County near the Michigan Secondary Governmental Complex (RF 23012, 03635A). The location and approximate length of the job are shown in Figure 1. This project was chosen for the test work because of its relatively small size and its close proximity to Lansing.

CONSTRUCTION PROCEDURES

Preparation of Cold-Mix Base Material

The base material was mixed at the Reith-Riley asphalt plant on Creyts Rd during the period from May 10 to May 17, 1976. The materials used were a 20A aggregate and MS-2S asphalt emulsion mixed with a Kolberg continuous-flow mixer. The mixed material is shown in Figure 2. The asphalt emulsion was sampled by the Department's bituminous plant inspector at the job site, and sent to the Testing Laboratory in Ann Arbor for analysis. The results of those tests indicated that all samples were within specification limits.

Results of the extraction tests on the mixture show an average asphalt content of 4.56 percent. There were no problems in mixing and handling the material after proper adjustment for the asphalt flow in the mixer was made. The mixed material was stockpiled at the Reith-Riley plant until the road construction was started on July 12, 1976.

Preparation of Subgrade

The subgrade material was generally a non-plastic sandy-loam, as shown in Figure 3. After the subgrade was placed and shaped, soil borings were taken and the material approved for highway use. In-place density tests were conducted by a density inspector from the Construction

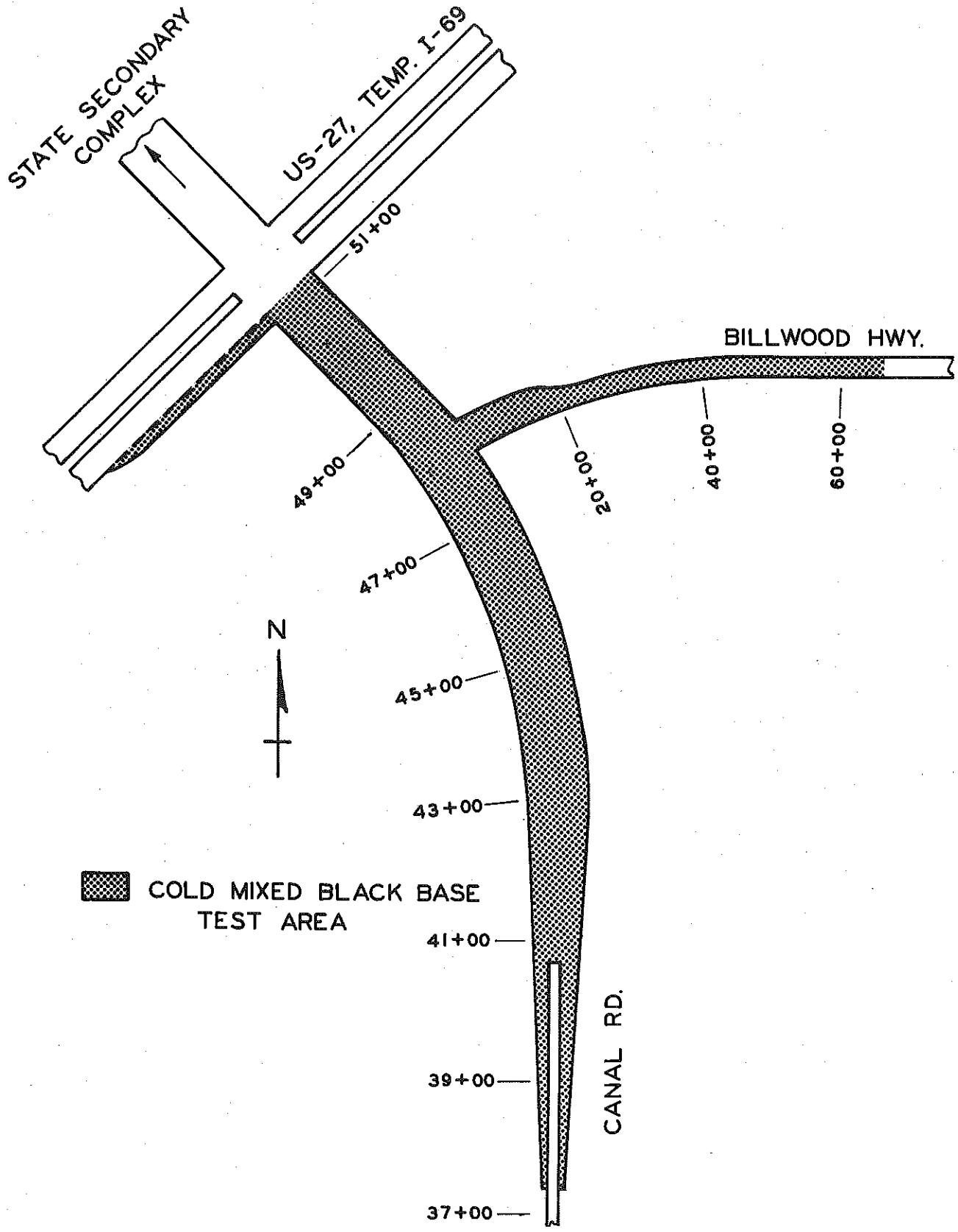


Figure 1. Location map of Research Project 75 E-55.

Figure 2. Prepared base material.

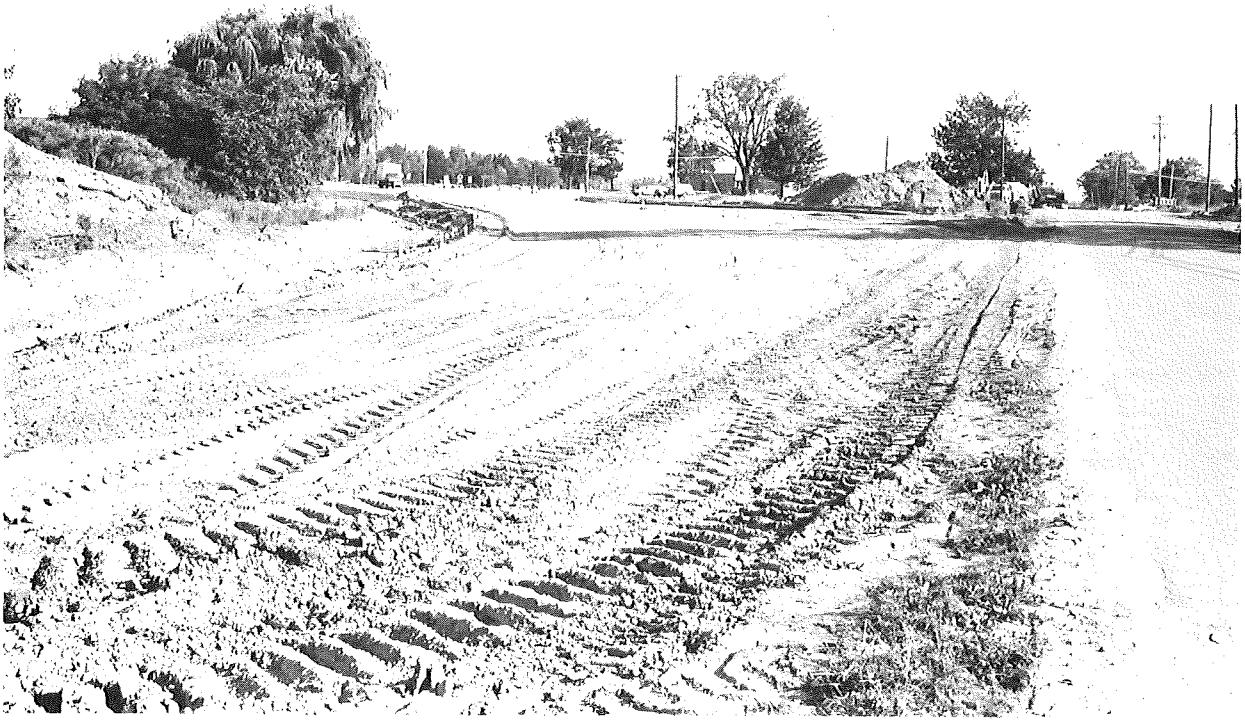


Figure 3. Subgrade material on Canal Rd.

Placement of cold-mix black base on subgrade.

Spreading cold-mix black base to desired depth.

Aerating cold-mix black base.

Figure 4. Original construction procedures.

Division, and the values are presented in Table 1. All of the subgrade was approved by the Construction Division before any base material was placed.

TABLE 1
IN-PLACE DENSITY MEASUREMENTS
ON SUBGRADE

	Station	Moisture Content, percent	In-Place Dry Density pcf	Maximum Density, pcf	Optimum Moisture Content, percent	Percent Compaction
Canal Rd	44+00	10.4	108.2	114.1	14.9	94.8
	45+75	14.3	118.4	111.5	15.8	106.2
	46+50	9.9	115.3	115.0	14.8	100.3
	46+70	11.0	107.1	114.1	14.9	96.1
	48+00	6.8	115.0	115.0	14.8	100.0
	49+50	13.3	121.3	111.5	15.8	108.8
	50+26	7.4	108.7	108.6	17.2	100.1
	50+30	7.2	104.7	108.6	17.2	96.4
	50+50	4.6	113.6	115.0	14.8	98.8
	50+50	9.9	114.5	115.0	14.8	99.6
Billwood Hwy	10+00	2.9	117.0	118.7	13.5	98.6
	10+00	7.2	113.3	113.3	15.1	100.0
	12+00	9.0	113.0	113.3	15.1	99.7
	14+00	12.3	108.8	113.3	15.1	96.0

Cold-Mix Black Base Construction

Placement of the black base material began on July 12 on Canal Rd just south of US 27. The base material was placed on the subgrade, without a prime coat, by end dumping directly from the trucks. A bulldozer was used to spread the material over the entire width of the roadway to the desired depth. Shortly after the material was spread, aeration was started using an agricultural harrow pulled by a conventional tractor. These phases of the operation are shown in Figure 4. Aeration of the material was conducted continuously the remainder of the day, and throughout the next day. It was felt that the moisture content of the base would be critical for proper compaction, but at this time no moisture limits had been determined. In

an attempt to determine proper moisture limits under field conditions and to evaluate the efficiency of the aeration equipment being used, periodic moisture measurements were taken using a Speedy Moisture Tester (Model M-330). The results of those tests are given in Table 2. This testing indicates that the aeration equipment was only effective in removing part of the existing moisture, and beyond that point continued aeration was inefficient. From these data it was not possible to establish moisture limits for compaction, however it was noted that samples having 3 percent or higher moisture felt mushy when handled, and appeared to contain excess moisture.

TABLE 2
MOISTURE DETERMINATION OF
COLD MIXED BLACK BASE DURING
INITIAL AERATION (CANAL RD)

Date	Station	Time	Moisture Content, percent
7-12-76	50+50	10:45 a.m.	6.3
7-12-76	50+00	2:30 p.m.	3.0
7-13-76	50+00	8:15 a.m.	2.6
7-13-76	49+00	8:30 a.m.	3.0
7-13-76	48+00	8:40 a.m.	1.6
7-13-76	50+00	10:30 a.m.	2.5
7-14-76	50+00	9:00 a.m.	2.3

Note: All samples are representative of the entire depth of material placed.

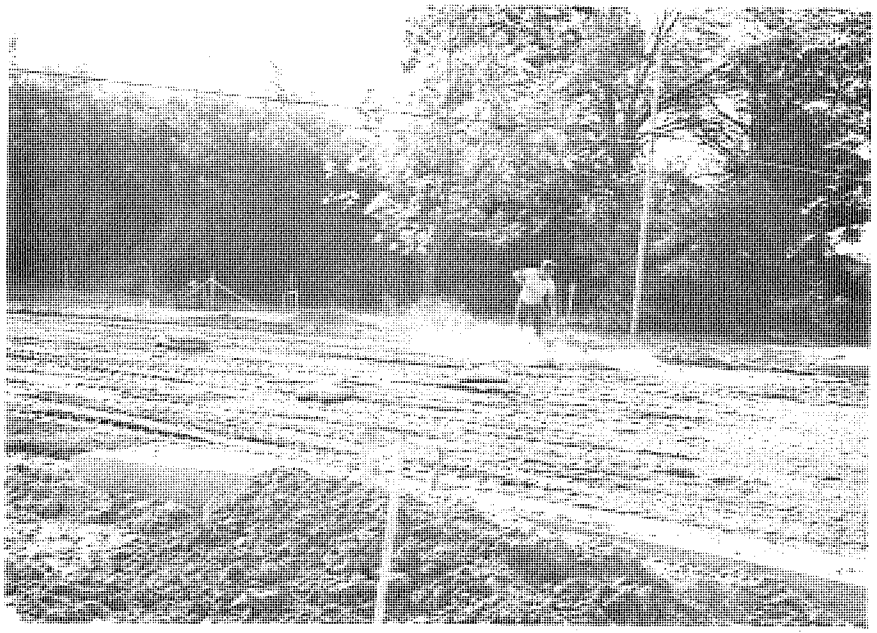
The project proposal called for the base material to be constructed in layers of 3 in. maximum depth. Material was continually added in several layers until a thickness of about 8 in. had been placed. This thickness made it impossible for the equipment being used to aerate the entire depth. On July 13, at about 3 p.m. Speedy moisture tests were taken on the top 4 in. of material and on the bottom 4 in. of material indicating excessive moisture contents of 3.0 and 4.6 percent, respectively. This moisture variation was brought to the contractor's attention and efforts were made to set

Figure 5. Aeration of cold-mixed black base. The dozer was necessary to pull aeration equipment trying to mix the entire 8-in. of material.

the harrow deeper to aerate the bottom layer (Fig. 5). On July 14, initial compaction of the base material was conducted at 7:00 a.m. with a rubber tired roller, and the material seemed to be firm with no apparent soft areas. A moisture test taken at a typical location, at 9:00 a.m. indicated a moisture content of 2.3 percent. This moisture content was considered acceptable as the base did seem firm and well compacted at this test site. Also, this moisture content was below the limit established later in this report where moisture contents of several firm and adjacent soft base areas are compared, as shown in Table 3.

Construction Problems

The major problem in using cold mixed black base on this construction project was the presence of excess moisture. This moisture problem made it necessary to aerate the material for several days before compaction could be conducted. On July 14, after the material was compacted, the contractor planned to start placing the bituminous concrete leveling course at about 3:00 p.m. However at about 2:00 p.m. several soft and cracked areas appeared in the base. Upon investigating these areas it was found that the top 4 in. of material was dry and hard but the bottom 4 in. was soft and mushy. Speedy moisture tests were run on both layers indicating 1 percent on the top and 5 percent on the bottom layer. Because this situation



Adding portland cement to the cold-mix black base.

Portland cement spread over entire test strip.

Mixing portland cement into cold-mix black base.

Figure 6. Experimental test strip on Billwood Hwy.

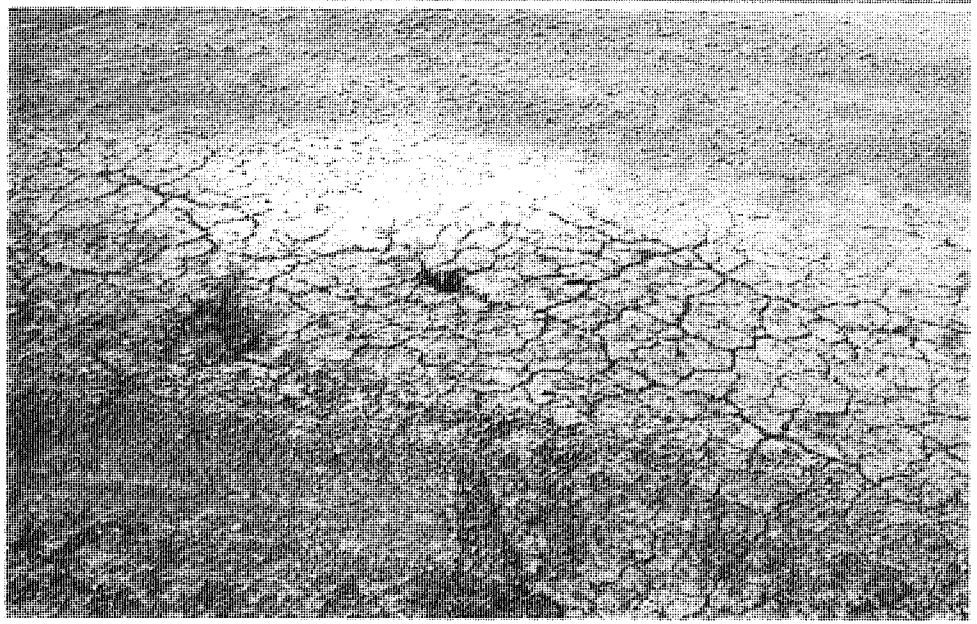
was evident in several areas throughout the job, the paving operations were postponed, and the contractor resumed aeration of the material. With the type of equipment being used, however, the contractor was not able to mix the entire 8 in. of material. After several days of aerating and trying to compact the material, with little success, two plans of action were discussed to attempt to speed up the operation. One was to scrap the cold mix base and do the entire job with hot mix base; the other was to make use of the cold mix base by adding a stabilizing agent to it. At this time 30 percent of the material scheduled for Canal Rd had been placed, and the remainder was already mixed and stockpiled. For this reason it was decided to use the cold mix base with the necessary modifications.

TABLE 3
MOISTURE CONTENTS FOR SEVERAL FIRM AND SOFT BASE AREAS ON CANAL RD

Site Number	Moisture Content, percent		
	Firm	Soft	Subgrade
1	1.5	4.0	10.6
2	0.4	3.8	12.1
3	2.2	2.7	7.8
4	0.5	3.1	14.5
5	0.6	4.1	9.3
6	2.5, 2.7	3.9	7.5
7	---	4.6	4.2
8	---	5.1	11.3
9	---	4.6	6.9

A small test strip on Billwood Hwy was constructed using base material from the stockpile, to which was added 2 percent portland cement. It was felt that the portland cement would take care of the excess moisture and also help harden the base material. This test strip was constructed on July 26, as shown in Figure 6. About 3 in. of base material was placed, the portland cement mixed into it, and the mixture compacted. The entire operation, from initial aeration to compaction, was completed in an hour. The initial moisture content of the base material was 6.7 percent, and at the time of compaction the moisture content was 6.4 percent. Therefore, very little drying occurred due to aeration and the addition of portland cement did not reduce the moisture content immediately. It was felt that,

Canal Rd just south of US 27, showing numerous rutted areas.



Canal Rd showing cracked and rutted areas.

Intersection of Canal and Billwood. Typical cracking in an area which is unstable because of excess moisture in this cold-mix base material.

Figure 7. Cracked areas in the base shortly after completion.

even with this high initial moisture content, in time the portland cement would take care of a substantial portion of the moisture and also help harden the base. Inspection of the test strip on July 27, indicated the process was successful. Reasonable hardening occurred in this test strip with the moisture content at 6.4 percent except for a few small unstable areas. By requiring an upper limit of 4 percent moisture before adding the portland cement it was felt that adequate stability could be readily achieved over the entire area. It was also felt that better mixing of the cement could be achieved with a mixer specifically designed for stabilization purposes.

Laboratory tests were conducted to evaluate the strength characteristics of both treated and untreated material, and the results are presented in Table 4. These tests show an average increase in stability of 82 percent due to the addition of portland cement. The success of this test strip led to the decision to treat the entire job in a like manner with the following changes. A multipass stabilizer mixer was to be used for aerating and mixing the portland cement, and a maximum moisture content of 4 percent was allowed in the base before adding the portland cement. This procedure was followed for the rest of the job with generally good results.

TABLE 4
MARSHALL STABILITY STRENGTH ANALYSIS
OF COLD MIXED BLACK BASE

Sample Type and Condition	Total Density, pcf	Moisture Content, percent	Stability, lb	Flow, 1/100-in.
Untreated: Dry	142.2	3.31	746	8.9
Soaked 24 hrs	142.4	3.31	508	8.1
I*	---	--	68.1%	--
Cement Treated: Dry	138.4	2.21	1305	11.1
Soaked 24 hr	138.2	2.21	964	9.0
I*	---	--	73.9%	--

* I = Index of Retained Strength = $\frac{\text{Soaked Stability}}{\text{Dry Stability}}$

Shortly after the base material was placed and compacted, using the modified procedure, several soft areas again appeared in the base (Fig. 7). A check of these areas indicated that there was still an excess amount

of moisture present. To determine if there was excess moisture in the subgrade as well, and to establish an acceptable moisture content for the base material, several soft and adjacent firm base areas throughout the job were selected and moisture contents determined. These data, presented in Table 3 indicate that there was no excess moisture in the subgrade, all of the moisture contents being below the optimum values determined during in-place density testing. An acceptable moisture content for the cold-mix base material was established by comparing the highest moisture content of the firm areas with the lowest moisture content of the soft areas, presented in Table 3. It was concluded that 2.7 percent was the maximum allowable moisture content for a stable base.

After several weeks of observing these cracked areas and numerous discussions, it was decided to remove the base material in these areas and replace it with hot mixed bituminous material. The amount of material replaced was 1,716 sq yd at a cost of $26,534. This work was started on September 8 and finished on September 10, 1976. After completion of this work an inspection of the job indicated that the base was in good condition, so the bituminous concrete leveling and wearing courses were applied, and the road opened to traffic. Visual inspection of the road a month after completion indicated no apparent problems. Future visual inspections will be conducted periodically.

CONCLUSIONS

Based on field observations of this project and discussions with construction personnel, the following conclusions are made:

1) The major problem encountered with the asphalt emulsion base was one of excess moisture and an inability to remove that moisture effectively. Even with careful moisture control, the addition of portland cement, and proper aeration, soft areas were still a major problem. The unpredictability, with respect to moisture control, found during this job makes this material highly questionable for use in general highway construction.

2) There were no problems with preparing and stockpiling the mixture.

3) The base did seem firm when properly dried and compacted.